Remarks

Claims 1-33 were pending in the present application, of which claims 6, 7, 13, 20, 28 and 30 have been cancelled without prejudice or disclaimer of the subject matter therein. By this amendment, new claims 34-39 have been added. It is respectfully submitted that the pending claims define allowable subject matter.

Claims 1-2, 4-6, 8-17 and 19-29 and 31 have been rejected under 35 USC § 102(b) as being anticipated by Lipschutz. The remaining claims have been rejected under 35 USC § 103 as being unpatentable over Lipschutz in view of various secondary references including O'Donnell, Lockwood, Safranek, Phelps and Ikeda. Applicants respectfully traverse these rejections for reasons set forth hereafter.

The claims generally recite ultrasound sub-aperture beamforming probes and methods of performing sub-aperture beamforming, where each independent claim clearly recites signal processors and cache memory held within the housing of a handheld ultrasound probe. The claimed methods and apparatus further recite particular coupling between the transducer elements to define receive sub-apertures, as well as directional parameters stored in the cache memory in the ultrasound probe. The directional parameters are used by the signal processors in the ultrasound probe to effect receive sub-aperture beamforming on a beam by beam basis. The prior art fails to teach or suggest the claimed structure or methods.

In each of the outstanding rejections, the patent to Lipschutz is relied upon solely or in combination with secondary references. However, the system of Lipschutz is not directed to an ultrasound beamformer for performing sub-aperture beamforming within an ultrasound probe. Lipschutz describes a time multiplexed digital ultrasound beamformer. Lipschutz does not suggest any portion of the beamforming operation to be performed within the ultrasound probe, but instead follows the conventional practice of performing all beamforming operations at the remote ultrasound scanner that is coupled to the ultrasound probe over a system cable.

Lipschutz describes a probe 10 which is coupled to the system scanner that holds the complete receive beamformer 12. As support for this understanding, attention is directed to paragraph 5, lines 13-16 in which Lipschutz describes the transducer as a separate structure from transmit and receive beamformers, where each of the three components collectively form parts of a scanner. At column 5, lines 61-63, it is explained that different transducers with different

frequencies may be used with the system, while at column 6, lines 11-15, it is explained that, depending on the transducer used, one or more receive beams can be processed by the beamformer. The foregoing are simply examples of the discussion of Lipschutz that emphasize the fact that Lipschutz contemplates the entire receive beamformer to be housed at the remote scanner separate from the ultrasound probe. Thus, Lipschutz does not teach or suggest the claimed ultrasound probe configuration and method of performing receive sub-aperture beamforming within the probe.

Further, Lipschutz does not perform sub-aperture beamforming. The claims clearly define transducer elements to be coupled to signal processors within the ultrasound probe housing, where each plurality of transducer elements defines a receive sub-aperture. The cache memory and signal processor perform the claimed operations relative to receive sub-apertures. Lipschutz does not discuss, nor contemplate, processing at a receive sub-aperture level, within the ultrasound probe or otherwise. In view of the foregoing comments, it is respectfully submitted that Lipschutz does not anticipate any of the pending claims.

The secondary references fail to make up for the deficiencies of Lipschutz. O'Donnell describes methods and apparatus for obtaining different return energy imaging beams responsive to a single excitation event. O'Donnell's system and method are not concerned with, and does not discuss, implementation of cache memory or signal processors within the housing of an ultrasound probe. Further, O'Donnell does not discuss or suggest arranging transducer elements in receive sub-apertures where processing associated with the sub-aperture is performed within the ultrasound probe housing on a beam by beam basis, based on directional parameters stored in cache memory in the ultrasound probe housing.

Phelps describes a receive ultrasound imaging system. Phelps receive circuit includes, within the transducer probe, elements 24 connected with a multiplexer 26 through pre-amplifiers 35, time gain circuits 37 and sample and hold circuits 60. The output of the multiplexer is provided through a line driver 30 over the system cable 22 to the base unit 12. In Phelps, there is no teaching or suggestion to provide cache memory within the probe 18 which stores directional parameters which are then used for sub-aperture processing. Further, Phelps does not teach or suggest arranging the elements 24 to define receive sub-apertures based on locally stored directional parameters.

Lockwood describes a sparse array structure that is entirely lacking of any specific teachings regarding the use of signal processors and cache memory within ultrasound probe housing. Lockwood is also void of any teaching or suggestion regarding the arrangement of transducer elements in receive sub-apertures and processing in connection therewith.

Safranek's computer system does not include any discussion of processing, or the content of an ultrasound probe, let alone the claimed use of signal processors and cache memory and receive sub-aperture arrangements.

Ikeda describes an ultrasound diagnosis apparatus having a probe A and mainframe B. The probe A has ultrasound transducer elements disposed in a one dimensional array configuration. The probe A includes a storage unit 2 which stores control data characteristic to the probe. The storage unit 2 does not store the claimed information, nor does the probe A include signal processors which perform the claimed operations. Instead, the storage unit 2 simply stores information identifying the type of probe A, such as the number of transducer elements, transmit signal delay data, and receive signal delay data. The transmit and receive signal data are fixed characteristics associated with a particular probe that are read by the controller 9 in the mainframe passed to a storage unit 13 in the mainframe and ultimately used at the beamformer 7 in the mainframe to effect transmit and receive operations. The information in storage unit 2 does not teach or suggest the claimed cache memory, nor the type of directional parameters stored in the ultrasound probe as presently claimed. The memory in Ikeda's probe A is used to inform the mainframe of the general type of probe and its configuration. The storage 2 is not used during operation in the claimed manner by signal processors within an ultrasound probe as claimed.

Further, Ikeda includes no discussion of processing receive sub-apertures. Ikeda's system is not concerned with, nor configured to, use transducer elements to define receive sub-apertures, nor is Ikeda's storage unit 2 capable of, or configured to, save directional parameters to be used by a signal processor within the probe housing to delay signals from a group of transducer elements that define a selected receive sub-aperture.

Based on the foregoing, it is respectfully submitted that the person of ordinary skill would not have been motivated to combine the teachings of the various above discussed references in any manner that would render obvious the claimed invention. As outlined above,

each and every reference has one or more deficiencies and in combination thereof does not render obvious the claimed methods and systems.

In view of the foregoing comments, it is respectfully submitted that Lipschutz fails to teach or suggest the claimed invention. Should anything remain in order to place the present application in condition for allowance, the Examiner is kindly invited to contact the undersigned at the telephone number listed below.

Respectfully Submitted,

Date: April 12, 2007

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